

TRANSPORTATION COST SYSTEM (TRACS) Documentation

I. PREFACE

A. Purpose and Content

USPS-FY19-36 documents the development of the estimated distribution keys for purchased transportation costs. It contains documentation for the two Transportation Cost System (TRACS) subsystems, TRACS Air and TRACS Surface (Highway), used to develop these costs. It also presents FY19 CV's (coefficients of variation) and confidence intervals for TRACS estimates.

B. Predecessor Document(s)

The development of the TRACS estimated distribution keys and C.V.s material was presented in Docket No. ACR2018 USPS-FY18-36.

C. Corresponding Non-Public or Public Document

A non-public version of this document is provided as: USPS-FY19-NP24 Transportation Cost System (TRACS).

D. Methodology

TRACS implemented the following methodology changes in FY19.

Changes have also been made to use a proxy input distribution in TRACS Air Night Turn Model due to a lack of specific ACT Tag data in Postal Quarter 2.

E. Input/Output

The TRACS distribution keys are used to develop purchased transportation costs as inputs to:

USPS-FY19-32 FY19 CRA "B" Workpapers,
USPS-FY19-NP14 FY19 CRA "B" Workpapers, and
USPS-FY19-NP2 FY19 International Cost & Revenue Analysis (ICRA) Report.

II. ORGANIZATION

USPS-FY19-36 contains the relevant source code and outputs from TRACS. The 'README_TRACS' file describes the contents of USPS-FY19-36, which include an Excel file containing the C.V.s (coefficients of variation) for TRACS. The programs and systems used to develop the TRACS estimated distribution keys are described in the sections below. The documentation is contained in three appendices:

- **Appendix A : Surface Subsystem**
- **Appendix B : Air Subsystem**
- **Appendix C : Tables**

III. PROGRAM AND SYSTEM DOCUMENTATION

Since the TRACS Surface and Air subsystems are dissimilar, each subsystem is addressed separately in its own appendix.

The following table shows the TRACS Air and Surface subsystem sample sizes, by quarter for FY19

TRACS Sample Size by Quarter: FY19

Postal Quarter	FedEx Day	UPS	Com. Air	Surface	Total
Q 1	850	270	540	3117	4827
Q 2	850	270	540	3115	4825
Q 3	850	270	540	3115	4825
Q 4	850	270	540	3114	4824
FY19	3400	1080	2160	12461	19301

Appendix A: TRACS Surface (Highway) Subsystem

I. Overview

The TRACS Surface (Highway) subsystem is a continuous, ongoing statistical sampling system. On a quarterly basis, it produces an independent distribution key for each of five transportation modes representing four purchased highway contract groups: Inter-NDC¹, Intra-NDC, Inter-SCF² and Intra-SCF, and VSD (vehicle service drivers).

The primary sampling unit (PSU) for the four purchased highway contract modes is a mode-route-trip-stop-day, which is defined as all mail unloaded from a truck (van or vehicle) at one facility for a specific trip and day combination. The PSU for the VSD mode is defined as a mode-origin-destination-DOW-window, where DOW and window correspond to a day-of-week and arrival time segment combination, respectively. The survey design is essentially the same for all five modes, though each has its own sampling frame. Each surface mode sampling frame is a list of PSU's³.

TRACS Surface utilizes a stratified, multi-stage sample design. The sample design consists of three selection stages for the four highway contract modes and four selection stages for the VSD mode. For a highway contract mode, the stop-days are stratified based on the type of facility and whether the trip is inbound or outbound. A systematic random sample of stop-days is selected from each stratum.

For the Inter-NDC mode, the PSU's are stratified into three groups according to the facility type as follows: Group-1 consists of truck stops at NDC facilities; Group-2 represents truck stops at SCF facilities; Group-3 represents truck stops at other facilities (not Group-1 or Group-2).

For the Intra-NDC mode, the PSU's are stratified into five groups according to the facility type, along with whether the trip is inbound or outbound as follows: Group-1 consists of inbound or outbound truck stops at NDC facilities; Group-2 represents inbound truck stops at SCF facilities; Group-3 represents inbound truck stops at non-SCF and non-NDC facilities; Group-4 represents outbound truck stops at SCF; Group-5 represent outbound truck stops at non-SCF and non-NDC facilities .

¹ Network Distribution Center (formerly Bulk Mail Center).

² Sectional Center Facility.

³ Abbreviated name for a PSU in TRACS Surface is a 'stop-day'.

For the Inter-SCF mode, the PSU's are stratified into three groups according to the facility type as follows: Group-1 consists of truck stops at NDC facilities; Group-2 represents truck stops at SCF facilities; Group-3 represents truck stops at other facilities (not Group-1 or Group-2).

For the Intra-SCF mode, the PSU's are stratified into five groups according to the facility type, whether the trip is inbound or outbound, along with arrival time as follows: Group-1 consists of inbound truck stops at SCF or NDC facilities; Group-2 represents inbound truck stops at non-SCF or non-NDC facilities; Group-3 represents outbound truck stops at SCF or NDC facilities; Group-4 represents outbound truck stops at non-SCF or non-NDC facilities with an arrival time before 1200; Group-5 represent outbound truck stops non-SCF or non-NDC facilities with arrival times starting at 1200 or later.

For the VSD mode, the PSU's are stratified into three groups according to origin and destination facility type along with 2-hour arrival window as follows: Group-1 consists of truck stops at mail processing facilities (other than Group-3); Group-2 represents truck stops at non-mail processing facilities; and Group-3 represents trucks leaving non-mail processing facilities during late night or early morning hours that stop at mail processing facilities. For the VSD mode, the PSU's are selected probability proportional to size (PPS) where the size measure is the expected number of arriving trucks. A single arriving truck SSU (secondary sampling unit) is then randomly selected for measurement.

At the second sampling stage (third stage for VSD mode), a sub-sample of pallets, containers and non-containerized loose items⁴ off-loaded at the test facility is selected. From each container (wheeled or other) selected at this stage, a final third-stage (fourth-stage for VSD mode) sample of items is selected for the highway contract or VSD mode, respectively. For pallets and non-containerized loose items selected at the second-stage (third-stage for VSD mode), there is no subsequent third-stage (fourth-stage for VSD mode) sample, i.e., all mail (all pieces if one or more) is recorded.

Weight and volume information by mail category is recorded for the contents of sampled items. For sampled letters and flats, weight (lbs.) data are converted to cubic-feet based on Density Study information. For sampled parcels, cubic-feet information are obtained directly from recorded parcel dimensional information (length, width and height) captured during sampling. For parcels for which dimensional data are incomplete, cubic-feet are obtained from the product of their recorded weights and reciprocal composite, four-quarter based density factors, by mail category. For sampled pallets, the dimensions of the pallet and the percentage of mail on the pallet by mail category are recorded. Data collectors also record the facility where the item, or the pallet, was loaded onto

⁴ Loose items include pieces, parcels, bundles, sacks, trays, or tubs. Items that are not in containers (wheeled or other) or on pallets are termed *non-containerized* loose items.

the vehicle (to establish miles traveled), and the percentage of vehicle floor space occupied by palletized mail, containerized items, and non-containerized loose items (to establish cubic-feet utilized). From the sample data, the cubic-foot-miles transported for each mode are estimated by mail category. Distribution keys, proportions of cubic-foot-miles by mail category, are calculated for each mode.

II. Statistical Study Design

The universe under study is all mail moved by surface transportation among five modes as follows:

- Highway Contract Account: All mail whose costs accrue to the following highway contract accounts:

Inter-NDC: Account Number 53131 (regular Inter-NDC);

Intra-NDC: Account Number 53127 (regular Intra-NDC);

Inter-SCF: Account Numbers 53124 (regular Inter-SCF), 53609 (regular Inter-P&DC), 53614 (regular Inter-cluster), and 53618 (regular Inter-area); and

Intra-SCF: Account Numbers 53121 (regular Intra-SCF), 53601 (regular Intra-P&DC), and 53605 (regular Intra-district).

- Other than Highway Contract Account: All mail moved by VSD transportation.

These five modes are described in more detail as follows:

- Intra-SCF – Generally these contracts involve carrying mail back and forth between an SCF or Processing & Distribution Center (P&DC) and the Associate Offices (AOs) within its service area. Outbound trips distribute mail from the SCF to the AOs. Inbound trips collect mail from AOs and bring it to the SCF.
- Inter-SCF – These contracts primarily involve carrying mail between SCFs or P&DCs. Inter-SCF trips also stop at AOs along the way.
- Intra-NDC – This category of contracts primarily involves carrying mail between an NDC and other facilities within its service area. Outbound trips distribute mail from the NDC to the SCFs and AOs, while inbound trips collect mail from the SCFs and AOs and bring it to the NDC.

- Inter-NDC – These contracts primarily involve carrying mail between NDCs, but they often include stops at SCFs and some stop at AOs. A contract that involves service between an NDC and an SCF outside of the NDC’s service area may also be classified in this category.
- VSD – All non-contract mail moved among post offices, stations and branches, and other postal facilities, including air mail facilities as well as various private firms.

For the four highway contract modes, the following table provides the count of all stops by destination facility type in Q4, FY17:

Table 1: Contract Route Stops by Mode and Facility Type – Q4, FY19

Mode	NDC	SCF/P&DC /HSP	AO/ Others	Total Stops
Intra-SCF	31707	1291680	3857568	5180955
Inter-SCF	65286	785291	254384	1104961
Intra-NDC	73476	155584	36907	265967
Inter-NDC	49127	49816	6448	105391

Typically, one route entails multiple trips, some being round-trips and others being one-way trips. One trip serves a specific route on specific days of a week. A trip consists of one or more trip segments. A segment is a movement from one facility to the next facility along the trip. There are as many stops on a trip as there are segments. Therefore, a list of trip-segment-destinations is the same as a list of trip-stops.

Table 2: Highway Stratum definitions

Stratum	Inter-NDC	Inter-SCF
1	Stop at NDC	Stop at NDC
2	Stop at SCF	Stop at SCF
3	Stop at Other	Stop at Other
Srtatum	Intra-NDC	Intra-SCF
1	Stop at NDC	Inbound NDC or SCF
2	Inbound SCF	Inbound Other
3	Inbound Other	Outbound NDC or SCF
4	Outbound SCF	Outbound Other a.m.
5	Outbound Other	Outbound Other p.m.

For the VSD mode, the following table provides the total number of VSD truck stops (arriving trucks and vans), by sampling stratum in Q4, FY17:

Table 3: VSD Mode SSU's (Arriving Trucks) by Stratum – Q4, FY19

Type	Mail Processing	Non-Processing	Other	Total
VSD	815880	1046910	414388	2277178

1. First-Stage Sample (First- and Second-Stage for VSD Mode).

For each highway contract mode, the first-stage sample for a quarter is a stratified random sample selected from all possible PSU's (stop–days), where a PSU represents a route-trip-stop-day combination. Stops are stratified based on the type of facility and whether their segments represent inbound or outbound trips. Within each stratum, stops are sorted by district and a systematic random sample of stops is selected with probability proportional to the trip's operating frequency. For each selected stop, all possible operating days during the quarter are listed and a test date is randomly assigned from the list.

For the VSD mode, the first-stage sample for a quarter is a stratified random sample obtained from all possible PSU's, where a PSU represents an origin-destination-DOW-window combination. The DOW and window components of the PSU represent a S-M-T-W-R-F-S weekday and 2-hour time segment within (12 possible), respectively. The PSU's are stratified based on mail processing versus non-mail processing facility type, and for the latter stratum, late night or early morning hour versus all other departure times. The PSU's are selected probability proportional to size (PPS) without replacement (wor) within each

stratum and systematically, where the size measure for each PSU is the expected number of arriving trucks. On the assigned test date for a sampled stop-day, an arriving truck SSU (secondary sampling unit) is then randomly selected for measurement. The combined first- and second-stage sampling methodology (pps and fixed-size srs, respectively) provides an equal probability, self-weighting sample (and estimator) for which all arriving trucks (SSU's) in a stratum have the same (equal) probability of selection.

The following table shows the first-stage sample size by quarter for FY19.

Table 3: First-Stage Sample Size by Quarter – All Modes

Postal Quarter	INTRA SCF	INTER SCF	INTRA NDC	INTER NDC	VSD	Total Surface
Q1	750	716	550	551	550	3117
Q2	750	716	549	550	550	3115
Q3	749	716	549	551	550	3115
Q4	749	716	549	550	550	3114
FY19	2998	2864	2197	2202	2200	12461

2. Second-Stage Sample (Third-Stage for VSD Mode).

For each selected highway contract mode stop-day or equivalent VSD mode arriving truck, the following truck/van utilization data are recorded: (1) the percentage of floor space that is empty; this is further split based on the percentages of empty equipment and empty floor space; (2) the percentage of the floor space occupied by mail unloaded at the test facility; and (3) the percentage of the floor space occupied by mail that remained on the truck. The utilization data, based on square footage of floor space, are collected at the time the vehicle is opened, but before any mail is removed from or added to the vehicle.

The second-stage sample (third-stage for VSD mode) is a stratified sample of off-loaded containers, pallets and non-containerized loose items. Mail being off-loaded from the vehicle is stratified into five groups depending on the type of mail and the level of containerization. These five groups, or strata, are: pallets, containers (wheeled or other), non-containerized loose Express Mail, non-containerized sacks, and other non-containerized loose items. The percentage of floor space occupied by each group is first recorded before the sample is

selected for this sampling stage. The following rules are used to select the second-stage (third-stage for VSD mode) sample:

- Pallets: Up to two pallets are randomly selected.
- Containers: For containers (wheeled or other), if two or fewer containers are unloaded, all are selected. Otherwise, a random start and a skip interval of three are used to select containers for sampling. If the combination of the random start and skip interval results in the selection of fewer than two containers (a single container), then a second container is also randomly selected. At most, five containers are selected. For each sampled container (only), a subsample of items is randomly selected (see next section).
- Non-containerized loose Express Mail items: All non-containerized loose Express Mail items (sacks, parcels, etc.) are selected. All mail for each selected loose Express Mail item is recorded (i.e., all pieces if one or more).
- Non-containerized loose sacks and other non-containerized loose items: Up to eight non-containerized loose sacks and other non-containerized loose items are randomly selected, with at least one loose item of each loose item type. The item types sampled in TRACS are: trays, tubs, sacks, bundles, loose parcels and pieces, etc. Loose items are selected in proportion to their presence on the vehicle. All mail for each selected loose item is recorded (i.e., all pieces if one or more).

3. Third-Stage Sample (Fourth-Stage for VSD Mode) for Containers only.

The third-stage sample (fourth-stage for VSD mode) is a stratified sample of the items (see definition in preceding section) found in each randomly selected container (wheeled or other). Mail in the container is first stratified by item type, and then one item from each item type is randomly selected. If there are any loose items within a sampled container (containerized loose items), then up to four mailpieces are randomly selected from the loose parcels or mailpieces (letters or flats) under the loose item category. Prior to the selection of an item for each item type, the data collector records the container type and the percentage of the container occupied by each item type. This information is used to estimate the cubic-feet occupied by each item type in the container. All mail for each selected item is recorded (i.e., all pieces if one or more).

There is no third stage sample (fourth stage for VSD mode) for pallets or non-containerized loose items (Express Mail, loose sacks or other loose items) selected in the second stage (third stage for VSD mode): all mail (all pieces if one or more) is recorded for the selected pallets and non-containerized loose items.

4. Recording Data for Pallets and Items.

For each selected pallet or item, two types of data are recorded: item information and mail information. For pallets, the information includes the dimensions (height, length and width) of the pallet, and the origin facility code where the pallet was loaded onto the truck/van. The pallet dimensions are used for expansion; the facility code is used to determine the mileage traveled. For mail information, the percentage of pallet space taken up by mail for up to four mail categories is recorded.

In TRACS, the same information is recorded for items regardless of whether they are non-containerized or from containers. For items, in addition to the origin facility code, the routing barcode information and the item type are also required as a part of the item information. The item type determines which expansion formula applies. For the mail found in an item, the information recorded includes the number of pieces and weight by mail category. For letters and flats, weights (lbs.) are converted to cubic-feet based on density study factors as shown in Appendix C, Table 1(a). For parcels, cubic feet are obtained directly from recorded dimensional information. For parcels for which dimensional data are incomplete, cubic-feet are obtained from the product of their recorded weights and reciprocal composite, four-quarter based density factors, by mail category. Table 1(b) provides estimated FY17 YTD composite densities for parcels by mail category.

III. Estimation

Quarterly distribution keys are produced for the five surface modes: Inter-NDC, Intra-NDC, Inter-SCF, Intra-SCF and VSD. Data are expanded in a three-step process to obtain cubic-foot-miles by mail category for each mode. In the first step, the test data are expanded to the unloaded truck capacity. In the second step, cubic-foot-miles are calculated, accounting for all legs the mail traveled (on the test vehicle). In the third step, the cubic-foot-miles estimated from individual tests are expanded to represent all stop-days (PSU's) within each stratum and summed across strata to estimate cubic-foot-miles by mail category, by mode. For each mode, the ratios of cubic-foot-miles by mail category to total cubic-foot-miles (across all mail categories) constitute the distribution key.

The process differs slightly for the Intra-SCF and VSD modes given the difficulties of maintaining highway mileage files for the very large number of Intra-SCF and VSD routes and stops, along with the added difficulty of consolidating all of the segment data for each specific VSD route trip. The distribution keys for these modes are based on cubic-foot-legs rather than cubic-foot-miles. For each mode here, the distance component of the distribution key is set to one mile for each sampled stop-day. Because trips for these modes are typically short in

distance and highly concentrated in urban areas, and as a result, their lengths do not vary appreciably, the distance factor is less relevant than for the other highway modes; however, since these two modes share much of the same methodology and processes used for the other TRACS Surface modes, reference nevertheless is made to cubic-foot-miles, and legs or segments.

The computer program used to expand sample data and generate the distribution keys is: TRACSSMN.HWYqfy.EDITEXP.CNTL(ZEXP). It has four inputs:

- (1) TRACSSMN.HIGHWAY.PQqfy.EDITED.DATA,
- (2) TRACSSMN.CUFT.DEFAULT.FLAT.TEXT.FYfy, and
- (3) TRACSSMN.MAILCODE.FLAT.CODE.FYfy.
- (4) TRACSSMN.HWY.PARCDENS.DEFAULTS.PQqfy

The first input file listed is the final analysis file ('Z-file') that contains the clean sample data, with information necessary for expansion. The second input file provides the cubic-foot value for each of the various types of containers and items sampled in TRACS. The third file identifies the three-digit numeric codes for letters and flats by mail category along with their associated Density Study factors. The fourth file identifies the three-digit numeric codes for parcels by mail category, along with estimated composite four-quarter based density factors required for any parcels with incomplete dimensional data.

The following notation is used in the expansion process:

<i>h</i>	sampling stratum within mode: for Inter-SCF and Inter-NDC, h=1,2,3; for Intra-SCF and Intra-NDC, h=1,2,3,4,5; for VSD, h=1,2,3. See Section II.1 for stratum descriptions by mode.
<i>n</i>	number of tests (effective) performed in the quarter;
<i>i</i>	test index within a stratum (h);
<i>N</i>	number of frame units in the quarter;
<i>I</i>	frame index;
<i>Day</i>	number of days in a week that a vehicle operates;
<i>Capacity</i>	vehicle capacity in cubic-feet;
<i>%Empty</i>	percentage of vehicle space that is empty;
<i>%Unload</i>	percentage of space occupied by mail unloaded;
<i>%Remain</i>	percentage of space occupied by mail remaining on the truck;
<i>%Container</i>	percentage of space occupied by unloaded containers;
<i>%Pallet</i>	percentage of space occupied by unloaded pallets;
<i>%Express</i>	percentage of space occupied by unloaded Express Mail items;
<i>%Sack</i>	percentage of space occupied by unloaded non-containerized sacks;

<i>%Other</i>	percentage of space occupied by unloaded other loose items;
<i>S</i>	total legs traveled on this trip, up to the test stop;
<i>s</i>	segment index, or leg, on the trip $\{s=1,2,\dots,S\}$;
<i>o</i>	origin index – the segment of the origin facility where the item was loaded onto the vehicle $\{o\in 1,2,\dots,S\}$.
<i>miles</i>	segment mileage;
<i>r</i>	mail category $\{r\in R$: all mail category and shape combinations);
<i>w</i>	net weight of mail in pounds;
<i>d</i>	reciprocal density factor in cubic–feet/pound;
<i>cuft</i>	mail cubic–feet;
<i>cfm</i>	mail cubic–foot–mile;
<i>y</i>	distribution key for the quarter; and
<i>M,m</i>	second-stage (SSU) population and sample size (counts), respectively.

Although the expansion process begins at the bottom and works its way upwards, it is helpful to look at the formulation, conceptually, from the top down.

The distribution key estimator for the r^{th} mail category,

$$y_r = \frac{cfm_r}{cfm} = \frac{cfm_r}{\sum_r cfm_r},$$

is the ratio of the estimated cubic–foot–miles for the mail category, divided by the estimated total cubic-foot–miles. The estimated cubic–foot–miles for a mail category from the first–stage (second-stage for VSD mode) expansion process is:

$$cfm_r = \sum_h \sum_i^{n_h} w_h cfm_{hir}.$$

In the above estimator, w_h is the stratum weight, and cfm_{hir} is the cubic–foot–miles for a test. For a highway contract mode, the stratum weight accounts for the first-stage probability associated with selecting a PSU (i) in stratum (h). This is an unbiased Horvitz –Thompson type estimator (see Cochran, Sampling Techniques, 3rd edition, Theorem 9A.5, page 260). For the VSD mode, the stratum weight is the reciprocal of the probability of selecting an arriving truck SSU within PSU (i), which is constant in each stratum (h) owing to the self-weighting first and second stage sample design for the VSD mode. The estimate of cubic–foot–miles for a test is:

$$cfm_{hir} = \sum_{s=1}^S cuft_{hirs} \times mile_{his}$$

Here, $(cuft_{hirs})$ is the estimate of cubic–feet of mail traveling on the s^{th} segment and unloaded at the test facility (i), and $(mile_{his})$ is the mileage associated with the segment. Furthermore,

$$cuft_{hirs} = \sum_{o=1}^s cuft_{hiro}$$

where $(cuft_{hiro})$ is the estimate of cubic–feet of mail that was initially loaded onto the vehicle at the beginning of the o^{th} segment and unloaded at the test facility. The cubic–foot–miles for a test are calculated in the second step of the expansion process as explained at the beginning of Section III.

1. Expanding to Unloaded Truck Capacity.

Dropping the stratum subscript, the first step in the expansion process produces $cuft_{iro}$, which for the r^{th} mail category is the estimated cubic–feet of mail that was loaded onto the vehicle at the o^{th} facility and unloaded at the test facility, adjusted to the unloaded truck capacity.

The unloaded truck capacity, in cubic–feet, is the product of the vehicle capacity and the recorded percentage of capacity taken up by all mail unloaded at the test facility. It is also the sum of estimated cubic–feet of unloaded mail across all mail categories:

$$Unloaded_i = Capacity_i \times \%Unloaded_i = \sum_r cuft_{irS} = \sum_r \sum_{o=1}^S cuft_{iro}$$

All mail unloaded from the test vehicle is sampled. There are three types of second-stage (third-stage for VSD mode) sampling units: pallets, containers (wheeled or other), and non-containerized loose items. The unloaded cubic–feet of mail is developed by estimating the cubic–feet for each unit type separately, and then summing across the three sampling unit types. Hence,

$$cuft_{iro} = cuft_{iro}^{(Pallet)} + cuft_{iro}^{(LooseItems)} + cuft_{iro}^{(Containers)}$$

1a. Palletized mail expansion formulas.

At most two pallets are selected for each test. All mail on selected pallets is sampled as follows: data collectors measure the height (H), length (L), and width (W) of each selected pallet and enter the mail category and percentage ($\%p$) of the pallet space occupied by mail for up to four mail categories. Let j denote the sampled pallet index: $j=1$ and 2 . For the pallet loaded on the vehicle at the o^{th} origin facility, the actual cubic-feet on pallet j occupied by mail category r is

$$H_{ioj}W_{ioj}L_{ioj} \times \% p_{iroj} .$$

Hence the truck space taken up by mail class r , loaded at origin facility o , on unloaded pallets is:

$$cuf_{iro}^{(Pallet)} = Capacity_i \times \% Pallet_i \times \frac{\sum_{j \in o} H_{ioj}W_{ioj}L_{ioj} \times \% p_{iroj}}{\sum_{o=1}^S \sum_{j=1}^2 H_{ioj}W_{ioj}L_{ioj}} . \quad (1)$$

The data set 'PALLET' in the 'Z-file' contains all the sample data for pallets.

1b. Non-containerized loose item mail expansion formulas.

All non-containerized loose item mail found on the truck is sub-stratified into three groups: non-containerized Express Mail, non-containerized loose sacks, and other non-containerized loose items. The truck utilization percentages are collected for each. All non-containerized loose Express Mail found on the vehicle is recorded. For non-containerized loose sacks and other non-containerized loose items, a total of eight items (if eight or more items are present) is sampled.

Additional notation:

j	$j=1,2,\dots,J$	sampled Express Mail,
k	$k=1,2,\dots,K$	sampled sack
l	$l=1,2,\dots,L$	sampled other item ($K+L \leq 8$)
TW		tare weight of the item.

The mail recorded from the sampled items is expanded to the truck space taken up by each category of non-containerized loose items through a two-step process.

Step1. The net weight of the mail in the sampled item is expanded to the cubic-feet of the item by multiplying the item's gross cubic-feet by the proportion of cubic-feet occupied by mail category r as follows:

$$\begin{aligned}
cuft_{iroj}^{(g)} &= cuft_{ioj}^{(g)} \times \frac{cuft_{iroj}}{cuft_{ioj}} \\
cuft_{irok}^{(g)} &= cuft_{iok}^{(g)} \times \frac{cuft_{irok}}{cuft_{iok}} \\
cuft_{irol}^{(g)} &= cuft_{iol}^{(g)} \times \frac{cuft_{irol}}{cuft_{iol}}.
\end{aligned} \tag{2}$$

In equation (2), the letter- and flat-shaped portions or components of cubic feet ($cuft_{iroj,k,l}$) for mail category (r) in test (i) are each obtained as the sum of the product of the net weight and reciprocal density factor for the mail category, taken across all sampled items in the test. Appendix C, Table 1(a), provides a complete list of the density factors for letters and flats, by mail category.

In equation (2), for parcels with dimensional length, width and height information, the parcel component of cubic feet is obtained directly from dimensional length, width and height data. For any parcels with incomplete dimensional data, cubic feet are obtained from the product of their recorded mailpiece weights and respective composite (moving four-quarter) density factors, by mail category. The composite density factors are based on parcels with non-empty dimensional length, width and height information obtained from the current and prior three quarters. The composite density factor for a mail category (r) is formulated as the ratio of summed weight to summed cubic-feet, where both sums are taken across the combined current and prior three quarters. Appendix C, Table 1(b), provides a complete list of the composite density factors for parcels by mail category for FY17. Parcel densities are also provided by quarter and are found under the following file name:

TRACSSMN.HWY.PARCDENS.DEFAULTS.PQqfy.

The item's gross cubic-feet ($cuft_{ioj,k,l}^{(g)}$) in equation (2) varies, depending on the type of item, as follows:

- a) For trays, flat tubs and con-cons, the gross cubic-feet of the item ($cuft_{iol}^{(g)}$) is as shown in Appendix C, Table 2;
- b) For bundles and loose items, the gross cubic-feet of the item ($cuft_{ioj}^{(g)}$) or ($cuft_{iol}^{(g)}$) is the same as (equivalent to) the net cubic-feet of the mail in the item:

$$\begin{aligned}
cuft_{ioj}^{(g)} &= \sum_r cuft_{iroj} = cuft_{ioj} \\
cuft_{iol}^{(g)} &= \sum_r cuft_{irol} = cuft_{iol}
\end{aligned} \quad (3)$$

In equation (3), the letter, flat and parcel shape components of cubic feet ($cuft_{ioj,l}$) for non-containerized loose item categories (j, l) for a test (i) are each obtained similarly as described under the expansion of net weight to cubic-feet for sampled items in equation (2).

c) For sacks, pouches, and Express Mail, the gross cubic–feet of the item is the total cubic–feet of the mail plus the tare cubic–feet for the sack/pouch:

$$\begin{aligned}
cuft_{ioj}^{(g)} &= \sum_r w_{iroj} d_r + TW_j \times d_j = \sum_r cuft_{iroj} + cuft_j^{(Tr)} \\
cuft_{iok}^{(g)} &= \sum_r w_{irok} d_r + TW_k \times d_k = \sum_r cuft_{irok} + cuft_k^{(Tr)} \\
cuft_{iol}^{(g)} &= \sum_r w_{irol} d_r + TW_l \times d_l = \sum_r cuft_{irol} + cuft_l^{(Tr)}.
\end{aligned} \quad (4)$$

Tare weight (TW) in equation (4), is the difference between the gross and the net weight of the sampled item. In (4), the tare weight density factors (d_r) are shown in Appendix C, Table 3.

Step2. The gross cubic–feet of mail in a sampled item is further expanded to the truck capacity utilized by the three non-containerized loose mail sampling groups:

$$cuft_{iro}^{(LooseItem)} = Capacity_i \times \left[\begin{aligned} & \%Express_i \times \frac{\sum_j cuft_{iroj}^{(g)}}{\sum_{o=1}^S \sum_j cuft_{iroj}^{(g)}} + \\ & \%Sack_i \times \frac{\sum_k cuft_{irok}^{(g)}}{\sum_{o=1}^S \sum_k cuft_{irok}^{(g)}} + \\ & \%Other_i \times \frac{\sum_l cuft_{irol}^{(g)}}{\sum_{o=1}^S \sum_l cuft_{irol}^{(g)}} \end{aligned} \right] \quad (5)$$

All non-containerized loose item data are contained in the SAS data set 'FORM3L' in the 'Z-file'.

1c. Containerized mail expansion formulas.

Every third container, up to a maximum of five, is sampled. For each sampled container, the data collector records the percentage of the container taken up by each of the item types found in the container. One item is randomly selected for each of the item types. For each selected item, all mail is counted. The pieces and weight are recorded by mail category.

Additional notations:

c	Sampled container $\{c=1,2,\dots,C: C\leq 5\}$;
t	Item type, $t = \text{Parcel, Sack, ...}$
p	Percentage of container space taken up by the item type
CONTCUFT	Container size in cubic-feet.

The following three steps are taken to expand the containerized mail:

Step1. The net weight of the mail in a sampled item (t) in container (c) is first expanded to the gross cubic-feet of the sampled item (t) by multiplying the item's gross cubic-feet ($cuft_{ioct}^g$) by the proportion of the item occupied by mail category (r), as follows:

$$cuft_{iroct}^{(g)} = cuft_{ioct}^{(g)} \times \frac{cuft_{iroct}}{cuft_{ioct}} \quad (6)$$

In (6), the letter, flat and parcel shape components of cubic feet ($cuft_{iroct}$) for a containerized item (t) in test (i) are each obtained in similar fashion as described under the expansion of net weight to cubic-feet for non-containerized loose items in equation (2).

The item's gross cubic-feet ($cuft_{ioct}^{(g)}$) varies, depending on the type of item, as follows:

- a) For trays, flat boxes, and con-cons, the gross cubic-feet, $cuft_{ioct}^{(g)}$, is as shown in Appendix C, Table 2;
- b) For bundles and other loose pieces, the gross cubic-feet, $cuft_{ioct}^{(g)}$, is the same as the net cubic-feet of mail in the item, i.e.

$$cuft_{iocr}^{(g)} = \sum_r cuft_{iroct} = cuft_{iocr}.$$

In the above equation, the letter, flat and parcel shape components of cubic feet ($cuft_{iocr}$) for a containerized loose item (t), in container (c) in test (i), are each obtained similarly as described under the expansion of net weight to cubic-feet for sampled items in equation (2).

c) For sacks, pouches, and Express Mail, the gross cubic-foot, $cuft_{iocr}^{(g)}$, is the mail cubic-feet plus the tare cubic-feet of the sack:

$$cuft_{iocr}^{(g)} = \sum_r w_{iroct} d_r + TW_t \times d_t = \sum_r cuft_{iroct} + cuft_t^{(Tr)}.$$

The tare weight (TW) in (c) above is the difference between the gross and net weight of the sampled item. The tare weight density factors are shown in Appendix C, Table 3.

Step2. The gross cubic-feet of mail in a sampled item is further expanded to the sampled container:

$$cuft_{iocr}^{(g)} = \frac{CONTCUFT_c}{\sum_{o=1}^S \sum_t p_{iocr}} \sum_t \left(p_{iocr} \times \frac{cuft_{iroct}^{(g)}}{cuft_{iocr}^{(g)}} \right). \quad (7)$$

The container size, $CONTCUFT$, for various type containers can be found in Appendix C, Table 4.

Step3. The resulting gross cubic-feet of mail is finally expanded to the truck capacity utilized by all unloaded containers,

$$cuft_{iro}^{(Container)} = Capacity_i \times \%Container_i \times \frac{\sum_{c=1}^C cuft_{iroc}^{(g)}}{\sum_{c=1}^C CONTCUFT_c} \quad (8)$$

The SAS data set 'FORM3C' in the 'Z-file' contains all the containerized sample data.

1d. Total cubic-feet of mail unloaded.

The cubic-feet of mail loaded on a truck at origin (o) and unloaded at the test stop (i) is the sum of the three second-stage (third-stage for VSD mode) sampling unit types:

$$cuft_{iro} = cuft_{iro}^{(Pallet)} + cuft_{iro}^{(LooseItem)} + cuft_{iro}^{(Container)} . \quad (9)$$

When summed across origins and mail categories (r), we obtain the reported unloaded capacity of the vehicle:

$$Unloaded_i = Capacity_i \times \%Unloaded_i = \sum_r \sum_{o=1}^S cuft_{iro} .$$

2. Cubic-Foot-Mile Calculation.

Summing Equation (9) across all origin facilities (o) up to a specific leg produces the cubic-foot estimates for the mail that traveled on the leg:

$$cuft_{irs} = \sum_{o=1}^S cuft_{iro} . \quad (10)$$

Each sample record contains a complete list of legs the mail item traveled on the vehicle. For each leg, the sample record also specifies the origin and destination facilities and the highway miles between the two. The cubic-foot-miles for each leg are the product of the cubic-feet estimates ($cuft_{irs}$) and the highway miles ($mile_{is}$) for the leg. The cubic-foot-miles is the sum of such products across all legs:

$$cfm_{ir} = \sum_{s=1}^S \{cuft_{irs} \times mile_{is}\} . \quad (11)$$

The cubic-foot-mile calculation specified in equation (11) requires highway miles for all leg segments on sampled routes. The highway-mileage file contains highway miles for over 7,000 facility pairs, and covers over 90% of the Inter-NDC, Intra-NDC, and Inter-SCF routes. For the Intra-SCF and VSD modes, as explained at the beginning of Section III (*Estimation*), the cubic-foot-mile calculation differs slightly given the difficulties of maintaining highway mileage files for the very large number of Intra-SCF and VSD routes and stops, along with the added difficulty of consolidating all of the segment data for each specific VSD route trip. As a result, the default mileage used for the two modes is one (1) mile:

$$cfm_{ir} = \sum_{s=1}^S cuft_{irs} . \quad (12)$$

In equation (12), each VSD test (i) is assigned one segment ($S=1$).⁵

Prior to Base Year 2000, equations (11) and (12) were adjusted to account for the unused capacity, or empty space, on the truck. The expansion process in place since then adopts the '*compromise method*' introduced by the Postal Service and adopted by the Commission in Docket No.R2000-1 (Op. ¶3300). Mathematically, the compromise method is equivalent to removing the empty space adjustment from the expansion process as shown in equations (11) and (12).

3a. Distribution Key.

The test (i) level cubic-foot-miles obtained from equations (11) and (12) in the previous section are expanded to the stratum (h) level and are then summed across strata. The distribution key is a set of ratios of the expanded cubic-foot-miles for an individual mail category to the total expanded cubic-foot-miles summed across all mail categories:

$$y_r = \frac{\sum_{h=1}^H \left(\sum_{i=1}^{n_h} cfm_{ir} \right) w_h}{\sum_{r \in R} \sum_{h=1}^H \left(\sum_{i=1}^{n_h} cfm_{ir} \right) w_h} = \frac{cfm_r}{\sum_r cfm_r} = \frac{cfm_r}{cfm} . \quad (13)$$

The stratum weights (w_h) in equation (13) for the four highway contract modes and the VSD mode, respectively, are:

$$w_h = \frac{\sum_{I=1}^{N_h} Day_I \times 13}{n_h}, \text{ and}$$

$$w_h = \frac{M_h}{n_h m_{hi}} = \frac{M_h}{n_h}, \text{ where } m_{hi} = 1.$$

(14)

3b. Intra-SCF Global Express Guaranteed (GXG) and Within County Periodicals.

TRACS-Surface uses RPW volumes to develop the Global Express Guaranteed (GXG) key for the Intra-SCF mode. The distribution key proportions for Express

⁵ See introduction to Section III *Estimation*.

Mail International (EMI) and Global Express Guaranteed (GXG) are developed as follows: The combined values for all TRACS modes, except intra-SCF contract routes, are reported as EMI with corresponding values of zero for GXG. The EMI and GXG aggregated proportion for intra-SCF routes is reallocated to these subclasses in proportion to their total RPW weight.

TRACS uses RPW volumes with applied density and distance factors to develop the Within County Periodicals key for the Intra-SCF TRACS Surface mode. The distribution key proportions for Within County Periodicals and Without County Periodicals are developed as follows: The combined values for all TRACS modes, except highway intra-SCF contract routes, are reported as Without County Periodicals with corresponding values of zero for Within County Periodicals. The Within County and Without County Periodicals aggregated proportion for intra-SCF routes is reallocated to these subclasses in proportion to their total RPW weight/cube/distance factor.

3c. Canada vs. Rest of World (ROW) Foreign Origin LC/AO Air and Surface

TRACS uses RPW weights to disaggregate both the Foreign Origin LC/AO Air and Foreign Origin LC/AO Surface into Canada vs. ROW. The distribution key proportions for Canada LC/AO and ROW LC/AO are developed as follows: The Canada and ROW aggregated proportion for each mode is reallocated to each group in proportion to their total RPW weights.

4. Variance and Confidence Limits.

The distribution key specified in (13) is a combined-strata estimate of the ratio of *cfm* for each mail category (*r*) to total *cfm* across all mail categories. For designs involving two or more sampling stages where the first-stage sample size in each stratum is sufficiently large, an ultimate cluster estimate of the sampling variance, computed among PSUs within each stratum, can be obtained for the numerator and denominator components of the ratio. After expansion at all subsequent sampling stages (2, 3, etc.), only the first-stage design weight is required for each sampled PSU. To ensure that the sampling error estimates are conservative and not underestimated, the first-stage finite population correction (*fpc*) for each stratum's estimate is ignored (set to 1). For each mode and each stratum within, an ultimate cluster approximation is obtained as the estimate of sampling variance for the numerator and denominator variables. The sampling variance estimator for a combined ratio estimate is found in Cochran's Sampling Techniques (3rd), Section 6.11.

For normally distributed random variables, the upper and lower 95% confidence limits of an estimate (*x*) are:

$$x(1 \pm 1.96 \times CV(x)) \quad (15)$$

where $CV(x)$ is the coefficient of variation (CV) of the estimate, and

$$CV(x) = \frac{\sqrt{Var(x)}}{x} \quad (16)$$

Let C_q be the volume variable cost for quarter q , the annual volume variable cost c_r is thus:

$$c_r = \sum_q C_q y_{rq} \quad (17)$$

where y_{rq} is the quarterly distribution key estimate from equation (13). To calculate the confidence limits for the annual cost in equation (16), we apply (16) on (17):

$$CV(c_r) = \frac{\sqrt{Var(c_r)}}{c_r} = \frac{\sqrt{Var\left(\sum_q C_q y_{rq}\right)}}{c_r}$$

Since samples are drawn independently from quarter to quarter, the variance of the sum is the sum of the variances. The CV for the annual cost is thus:

$$CV(c_r) = \frac{\sqrt{\left(\sum_q C_q^2 Var(y_{rq})\right)}}{c_r} = \frac{\sqrt{\sum_q (C_q y_{rq})^2 (CV(y_{rq}))^2}}{\sum_q C_q y_{rq}} \quad (18)$$

The confidence limits of the annual cost can be readily calculated from equation (15).

Appendix B : TRACS Air Subsystem

I. OVERVIEW

The TRACS Air subsystem is a continuous, ongoing statistical sampling system developed to provide distribution keys for attributing purchased air transportation costs to mail categories. . The Fed Ex Night Turn carrier utilizes a cost-model to develop its distribution keys. Fed Ex Night Turn sampling was eliminated in FY14. Weight and cubic-foot based distribution keys are constructed for the major network air modes each postal quarter for this purpose. The universe under study is all mail transported by the major air carriers. These include Commercial Air, UPS, FedEx Day Turn, and FedEx Night Turn. Mail transported by air taxi, or under Alaska, Hawaii, HASP and Christmas network services is excluded.

The TRACS Air subsystem samples mail flown from an origin city directly to a destination city or on the first leg of an inbound flight or trip to the mode's hub. The sampling frame for an air mode is a recent historical extract of its assigned weight (lbs.) obtained from the Postal Service's Enterprise Data Warehouse (EDW). The EDW maintains historical routing data for each mail item (sack, tray, loose parcel, etc.) transported by air carrier, including the air mode, origin city, destination city, dispatch date, dispatch time, processing date and time, assigned weight, and primary mail class.

The TRACS Air subsystem sample design utilizes a stratified, multi-stage probability sample of mail. The primary sampling unit (PSU) at the first stage of sampling is a mail class, facility, date and time segment combination. The secondary sampling unit (SSU) is a mail item. The sampling element is a mailpiece. A sampled mail item is fully enumerated; wherein, all mailpieces contained in the mail item are measured. Data collectors capture routing information from each sampled mail item along with content weight and volume (count) by mail category. Appendix C provides a list of the mail categories measured under TRACS. The sample data are recorded into laptop computers using the Computerized On-Site Data Entry System (CODES).

The TRACS Air sample data are expanded each postal quarter sampling period using inverse sampling fractions for strata at each sampling stage along with control ratios utilizing known EDW weight totals. Annual estimates are obtained by summing the postal quarter estimates.

II. STATISTICAL STUDY DESIGN

The TRACS Air subsystem develops weight (pounds) and cubic-foot based distribution keys for volume variable costs associated with each air mode.

The universe under study is all mail transported by an air mode from a domestic origin to a domestic destination. Mail transported by air taxi, or under Alaska, Hawaii, HASP, or Christmas networks is excluded.

In mail operations, mailpieces are sorted into mail items, or handling units consisting of trays, tubs and sacks. A mail item may also be a loose parcel. A mail item assigned to an air mode gets scanned electronically and then tagged at a Transaction Concentrator (TC) machine located at an origin postal or private mailer facility. A TC is uniquely identified in the EDW by its alpha-numeric device-id code which is normally six characters. One or more workstations may be associated with a device-id at an origin facility, and one or more device-id's in turn may be associated with an origin facility. The tagging process attaches a dispatch and routing (D&R) tag to each scanned mail item. The D&R tag identifies air mode specific information including the air carrier, origin and destination city airport codes, item weight and primary mail class. The primary mail class is the Air Contract Transportation (ACT) tag code. A mail item is assigned an ACT tag code based on the predominant mail class of the mail item's contents. The major mail class codes are: F, P, E and I. These codes correspond to First-Class Mail, Priority Mail, Express Mail and International mail, respectively. All other ACT tag code mail class groups are designated 'O' for sampling purposes under the TRACS Air subsystem. The EDW maintains summary weight information for all assigned (tagged) mail items, by device-id, date, flight, and ACT tag code. ACT tag weight totals from the EDW are used in the expansion of the sample data.

A. First-Stage Sample

The PSU for a network air mode is a *mailclass*facility*date*time-segment* combination.⁶ The *mailclass* component is the ACT tag code. The *facility* component is the postal or private mailer site where mail items are assigned to the air mode. The *date* and *time-segment* components identify the date and sub-period when mail items are assigned. The assignment of mail items for a given mail class, facility and date combination may occur over various time segments. A time segment may be a 1–2 hour, 2–3 hour, or other period, including a 24 hour period. A time segment determines a unique PSU for a given mail class, facility and date combination.

Prior to each postal quarter, a sampling frame is constructed listing all PSUs expected during the upcoming sampling period. PSUs are stratified by weight (lb.) based size categories. Thresholds (boundaries) are dynamically formulated each quarter using a cumulative \sqrt{f} distribution method and a fixed number of strata.

⁶ All mail items assigned for air transport for a PSU are subject to sampling, including mail items trucked by an air carrier.

A specified fixed total sample size is allocated among the strata proportional to each stratum's historical weight from the EDW. Prior to the draw, the PSU's are ordered by size within each stratum and a skip sample is then selected after a random starting unit is chosen. Sample dates are randomly assigned to the selected sampling units from all possible non-holiday dates of operation (specific to each air mode) after the dates are ordered and partitioned into a minimum number of equal size (uniform) sub-periods for workload smoothing purposes.

B. Second-Stage Sample

The second stage SSU is a mail item transported by an air carrier on a first leg flight or trip. Examples of mail items include a sack, letter tray, flat tub, and loose parcel. All mail items assigned to a PSU for first-leg transport are subject to sampling.

For a sampled PSU, a sub-sample consisting of 10 mail items (minimum) if available is selected. This sample is assumed a simple random sample. The second-stage sampling frame is an implicit listing of all mail items assigned for air transport at all workstations for all device-id's at the origin facility. If there are fewer than 10 mail items available for sampling at a targeted PSU, then all mail items are selected and sampled. If no mail items are assigned for a targeted PSU, then the test is considered a zero-volume test, subject to administrative confirmation. If a test is missed, it is rescheduled to the same weekday of a future week during the sampling period (unless it is within the last week of the quarter – then rescheduled to any weekday). The mail item population counts necessary for second-stage post-stratification and expansion are obtained from the EDW.

For each sampled mail item, PSU specific routing information is recorded directly into the data collector's laptop CODES computer. The routing information links the sample and EDW frame file records during the data editing and pre-expansion processes. No tertiary stage of sampling is conducted. A census is conducted of each SSUs contents, *i.e.*, all mailpieces (sampling elements) in a selected mail item are measured. Mailpiece volume and weight totals are recorded for each mail category in addition to the sampled unit's gross weight. The data collection procedures governing TRACS Air tests are documented in Section 8, of Handbook F-65, Data Collection User's Guide for Cost Systems, and the TRACS Air Reference Guide.

III. CREATING THE FIRST-STAGE SAMPLING FRAME

The frame of PSUs is constructed approximately five weeks in advance of the postal quarter from recent historical EDW information. The EDW provides

the following information for each mail item transported by air mode: device-id, three-character origin and destination airport codes, route identifier, route close-out date and time, ACT tag, assigned weight, and assigned date and time. This information is cross-walked to a file containing origin facility identifier information. The sampling frame for an air mode is a listing of all PSUs expected to have non-zero activity during the upcoming postal quarter.

PSU migrations among strata, including births and deaths occurring after sample selection or as a result of inadvertent sampling of non-targeted PSUs, are addressed through post-stratification prior to first-stage expansion.

IV. FIRST-STAGE SAMPLE SELECTION

A. Selecting the Sample

The total sample size is allocated among the primary strata proportionally to each stratum's recent historical mail weight (lbs.). Prior to this step, an empirical distribution is formulated to filter small-sized units at a prescribed percentile level. The measure of size for strata assignments is average weight (lbs.) by day-of-week (DOW) among PSUs having common mail class, facility and time segment components. Dates are temporarily collapsed to DOW for this purpose. The collapsed PSUs are assigned to strata using a cumulative \sqrt{f} distribution for the strata thresholds. The PSUs are then ordered within each stratum by their size measure. There are four different strata and they are classified as; 1) light, 2) medium-light, 3) medium-heavy, and 4) heavy. A starting unit is randomly selected between 1 and the computed skip interval length for each stratum. A second random assignment process provides the date component for each selected unit, from a mode-specific list of valid non-holiday operational fly dates for the sampling period.

After the random selection and date assignment processes, a workload smoothing process at the district level ensures that the randomly assigned dates for each weekday (Monday–Sunday) are distributed uniformly across equal-sized sub-periods of the full sampling period. Test facility information, including address and district code, is appended to each sample record for administration purposes.

V. PREPARING DATA FOR EXPANSION

Data validation and edit checks are made prior to data expansion. Sample data are checked for completeness, duplicate records, and integrity of field values. Sample data are extensively validated and crosschecked with EDW (linked by D&R barcode and processing date), the Product Tracking System PTS (linked by scanned mail piece barcode) and automatically scanned barcodes (mail piece barcodes scanned by the data collector). Sample data Act Tag

Codes, test dates, test facilities, time segments, air modes, and mail categories are independently checked. If the sample data are not independently vetted and confirmed with the EDW data, or if there is a conflict between PTS data or scanned barcodes, then the data are edited, if possible, or if not, then removed.

The Z-file contains unexpanded, edited sample data records for the TRACS Air subsystem. This file is produced in SAS program: TRACSSMN.FEDEX.PQqfy.CNTL(ZAIR04). Each Z-file record contains population and effective sample sizes for each sampling stage and stratum within, along with the EDW frame totals required to construct a distribution key estimate for each air mode.

In the Z-file program, updated EDW frame extract records are checked for missing values and duplicate records. A job abort is triggered if an empty field or non-unique record is encountered at the workstation and mail category level. The frame records for each subpopulation of an air mode are then post-stratified by weight at the PSU level. The original first-stage strata thresholds determined during sample selection are updated in this program to reflect changes occurring during the sampling period. The thresholds are formulated within each subpopulation using a cumulative \sqrt{f} distribution. The first-stage post-stratification process adjusts the original sampling frame for PSU migrations (births and deaths) across strata occurring after the sample was selected.

In the Z-file program, the sample data at the second stage SSU (mail item) level are post-stratified by workstation to incorporate known EDW mail class (ACT tag) totals into the second-stage expansion process. Prior to this step, the program checks the sample data records for missing variable values and non-unique mail class entries. A job abort occurs if either condition is found. Ounce-pound conversion and other data record checks and edits are conducted prior to this program. Non-countable sample records are summarized and reported before being bypassed from downstream processing. Effective second-stage sample sizes are appended to the sample data records during the second-stage post-stratification process.

The sample data records at the workstation and mail category within level are merged with frame records by PSU and mail class. Strata population counts and weight (lb.) controls for each sampling stage are appended. Effective first-stage sample sizes for sampled strata are appended in this step. Extraneous frame records for un-sampled PSUs and workstations are filtered. The merged data are output to the Z-file.

VI. EXPANSION

The data expansion process is similar for all air modes under the TRACS Air subsystem, with the exception of an average density factor to convert estimated weight to estimated cubic feet for FedEx Day Turn.

At the second stage of expansion, the sample data are post-stratified by workstation within each PSU and a mail category total is estimated for the PSU by a combined [strata] ratio estimator. In this process, the sample data for each secondary stratum (workstation) are expanded by the stratum's inverse sampling fraction, computed as the reciprocal of the ratio of the sample item count to the known mail item count from the EDW for the stratum. An intermediate control factor, computed as the ratio of known total weight for all device-id's in the PSU to known total weight for the sampled-only device-id's in the PSU, is applied to control for un-sampled device-id's. This factor is unity if a PSU has a single device-id or if at least one mail item is sampled from each device-id in the PSU. The combined [strata] ratio estimate of a total is computed for each mail category from the ratio of known total weight for the PSU to estimated total weight for the PSU (all mail categories combined).

PSU mail category estimates from the second stage expansion process are expanded to first-stage post-stratified classifications for each air mode subpopulation using a separate [stratum] ratio estimator. For the expansion phase, subpopulations are defined by facility type. The subpopulation groups for Commercial Air are: 1) private mailers, 2) the JFK International Service Center (ISC), and 3) all other postal facilities. The subpopulation groups for Fed Ex Day Turn and UPS are: 1) private mailers, and 2) all other postal facilities. For each mail category in a primary sampling stratum, the sum of the estimated PSU weight or volume totals in the stratum is expanded by the ratio of known total weight for the stratum from the EDW to the sum of estimated PSU total weight (all mail categories combined) for the stratum. For each mail category, the sum of the estimated strata totals in a subpopulation is controlled to known total weight for the subpopulation from the EDW. The control factor is unity if at least one PSU is sampled from each primary stratum.

A. Distribution Key Formulas

The TRACS Air subsystem produces distribution keys each quarter for each air mode based on weight, volume and cubic feet of mail. For a cubic-foot based distribution key, weight estimates are converted to cubic feet estimates using average densities (average lbs. per cubic foot) for specific mail class groups. Cubic-foot measures are unavailable in the EDW at the mail class level. As a result, a regression model is formulated to apportion EDW aggregated cubic feet to mail classes using known total weight and cubic feet for mixed city containers by mail class.

Program TRACSSMN.FEDEX.PQqyy.CNTL(DENSITY) is run each quarter for the air mode serving Priority Mail to develop density factors for P and F mail classes (ACT tag groups). In this program, known EDW total cubic feet (dependent variable) for all mail classes is regressed on known total weight for each mail class (independent variables) using historical origin airport and departure date data from the sampling period. The general formula associating total cubic feet (C) and mail class P or F total weight is:

$$(d.1) \quad C = C_P + C_F, \text{ or equivalently,}$$

$$C = (C_P / W_P) * W_P + (C_F / W_F) * W_F.$$

In the above equation, C_P / W_P and C_F / W_F are the reciprocal densities for mail classes P and F, respectively.

The general formula for the multiple linear regression model, fitting total cubic feet C to F and P total weight at the combined origin airport (o) and departure date (t) level, is:

$$(d.2) \quad C_{o,t} = d_P * W_{P,o,t} + d_F * W_{F,o,t}.$$

In equation (d.2), the coefficients d_P and d_F for the independent variables, $W_{P,o,t}$ and $W_{F,o,t}$, are the reciprocal densities shown in equation (d.1) at the origin-airport-day level.⁷

After density estimates are developed, they are adjusted to represent average densities relative to all mixed city and bypass container mail. The original and adjusted density ratios (d_F / d_P) and (d'_F / d'_P), respectively, are equal.

Electronic data records containing total weight and total cubic-feet measures for F and P mail classes, by origin airport and departure date, are extracted from SAMS invoice data in files named: TRACSSMN.DAY.DENSCUB.Qfyq.TXT, TRACSSMN.DAY.DENSLB.Qfyq.TXT. These files are inputs to the density program. Records pertaining to trucked routes, offshore airports and other air modes are filtered. To account for a lag between the flight departure date and the invoice date for flights on a weekend or Monday, records for the three days are collapsed to a single 'combined weekend' day for each origin airport, resulting in summary records for a 5-day week: Tuesday through Friday and the combined weekend day.

⁷ There is no intercept term in the equation since zero mail volume corresponds to zero cubic feet.

The adjusted densities for each quarter of FY 2019 are provided in the following table:

Day Turn Densities by Q for FY 2019

Q	F Density	P Density	Overall Density	Data obs.	t-value d_F	t-value d_P
1	6.02	6.12	6.10	4245	32.99	140.47
2	7.43	5.79	6.09	4334	47.35	226.12
3	9.50	5.36	5.94	4307	36.77	232.86
4	9.01	5.58	6.11	4180	44.63	238.74

The following variable and index notation is used in the sample data expansion formulas for the TRACS Air subsystem:

A: air mode.

c: mail class (ACT tag) component of PSU, $c \in C = \{E, P, I, F, "O"\}$.

d: device-id ($d \in D_c$).

D_c : the set of device-id's for a PSU reporting non-zero activity for the mail class component (*c*) of the PSU.

d'_P, d'_F : reciprocal density factors (adjusted) for mail class indexes: *P, F*.

h: 1st-stage index for post-stratification of PSU's into $1..L_h$ strata based on known (EDW) weight.

$i = 1, 2, \dots, nh$: PSU = mailclass*facility*date*time-segment (4 component combination) is the cluster number within stratum *h*, with a total of *nh* clusters.

$j = 1, 2, \dots, mhi$: SSU = mail item (mail handling unit, e.g., sack, tray, loose parcel, etc.) is the unit number within cluster *i* of stratum *h*, with a total of *mhi* units.

k: 2nd-stage index for post-stratification of SSU's into $1..L_k$ work-station-based strata.

M, m: 2nd-stage SSU population and sample sizes (counts), respectively.

N, n: 1st-stage PSU population and sample sizes (counts), respectively.

r: mail (rate) category element ($r \in \overset{P}{R}$).

$\overset{P}{R}$: estimated distribution key vector ($\overset{P}{R}$).

S: subpopulation (domain) in air mode (*A*).

w_{hij} : denotes the sampling weight for unit *j* in cluster *i* of stratum *h*.

x: sample weight (lbs) measure ($x \in y$) for ratio estimator auxiliary variable.

\hat{X} : estimated total weight (lbs.) for ratio estimator auxiliary variable (sum of estimated total weights for all $r \in \overset{P}{R}$).

X: known (EDW based) total weight (control lbs.) from database.

y: sample data measure of weight (lbs.), cubic feet or volume.

y_{hij} : observed values of the analysis variables for unit *j* in cluster *i* of stratum *h*.

\hat{Y} : estimated weight, cubic feet or volume total (*Y*).

At the second stage of expansion, the total (Y) for mail category (r) for a sampled PSU (i) in stratum (h) is estimated by a combined [strata] ratio estimator (Yrc)⁸, with subsequent control to known mail class (c) device-id weight totals, as follows:

$$(1.1) \quad \hat{Yrc}_{A,S,r,h,i} = \frac{1}{\delta} \left(\frac{\hat{Y}_{A,S,r,h,i}}{\hat{X}_{A,S,h,i}} \right) X_{A,S,h,i} \quad , \text{ where}$$

$$(1.2) \quad \hat{Y}_{A,S,r,h,i} = \left(\frac{\sum_{d \in D_c} X_{A,S,h,i,d}}{\sum_{d^* \in D_c} X_{A,S,h,i,d^*}} \right) \sum_{d \in D_c} \hat{Y}_{A,S,r,h,i,d} \quad , \text{ for}$$

$$(1.3) \quad \hat{Y}_{A,S,r,h,i,d} = \sum_{k^* \in d} \frac{M_{A,S,h,i,d,k^*}}{m_{A,S,h,i,d,k^*}} \sum_{j=1}^m y_{A,S,r,h,i,d,k^*,j} \quad , \text{ and}$$

$$(1.4) \quad \delta = \begin{cases} d_p, & \text{if } y = ft^3 \text{ and } (c) = P \\ d_F, & \text{if } y = ft^3 \text{ and } (c) \neq P \\ 1, & \text{otherwise,} \end{cases}$$

$$(1.5) \quad \hat{X}_{A,S,h,i} = \sum_{r \in R} \hat{Y}_{A,S,r,h,i} \quad , \text{ for } y = x, \text{ and}$$

$$(1.6) \quad X_{A,S,h,i} = \sum_{d \in D_c} \sum_{k \in d} X_{A,S,h,i,d,k} \quad .$$

In equation (1.2), d^* in the denominator of the ratio designates a device-id for PSU (i) for which at least one workstation (k) is represented in the captured sample data. If all device-id's in the PSU are represented in the sample, then this ratio is unity. In equation (1.3), k^* designates a sampled workstation stratum (post-stratified estimator) for which at least one SSU is measured. Equation (1.4) shows the adjusted density factors from equation (d.2) for the reciprocal density factor in equation (1.1) required to estimate cubic feet from the estimate of weight

⁸ To account for small second-stage sample sizes during post-stratification, a combined [strata] ratio estimator of a total is formulated in lieu of a separate [stratum] ratio estimator.

(used for Fed Ex Day Turn). In equation (1.6), known total weight for PSU (i) is obtained by summing the known total weights for all component workstations (k) for all device-id's (d) in D_c .

At the first stage of expansion for subpopulation (S) under air mode (A), total (Y) for a mail category (r) is estimated from the estimated PSU (i) totals in each primary stratum (h), $\hat{Y}rc_{A,S,r,h,i}$ in equation (1.1), by a separate [stratum] ratio estimator of a total, $\hat{Y}rs$, with subsequent controls to known total weight at the mail class (c) level, as follows:

$$(2.1) \quad \hat{Y}rs_{A,S,r} = \sum_{c \in C} \hat{Y}rs_{A,S,r,c} \left(\frac{\sum_{h \in c} X_{A,S,c,h}}{\sum_{h^* \in c} X_{A,S,c,h^*}} \right), \text{ where}$$

$$(2.2) \quad \hat{Y}rs_{A,S,r,c} = \sum_h \left(\frac{\sum_{i=1}^n \hat{Y}rc_{A,S,r,c,h,i}}{\sum_{i=1}^n \hat{X}_{A,S,c,h,i}} \right) X_{A,S,c,h}, \text{ for}$$

$$(2.3) \quad \hat{Y}rc_{A,S,r,c,h,i} \equiv \hat{Y}rc_{A,S,r,h,i} \text{ (from equation 1.1),}$$

$$(2.4) \quad \hat{X}_{A,S,c,h,i} = \sum_{r \in R} \hat{Y}rc_{A,S,r,c,h,i}, \text{ for } y=x,$$

$$(2.5) \quad X_{A,S,c,h} = \sum_{d \in D_c} \sum_{k \in d} X_{A,S,c,h,d,k}, \text{ and}$$

$$(2.6) \quad X_{A,S,c} = \sum_h X_{A,S,c,h}.$$

In equation (2.1), the expanded sample total, $\hat{Y}rs_{A,S,r,c}$, from equation (2.2) for mail class (c) in subpopulation (S) is controlled to the known total weight for all strata (h) comprising (c). This ratio accounts for empty (non-sampled) strata in mail classes within each (S), if any. In this equation, (h^*) denotes non-empty strata, for which sample data have been recorded. If sample data are recorded for all (h) in (S), then the ratio is unity. Empty(non-sampled) mail

classes for an entire mode and quarter substitute un-weighted sample data for the same mail class and quarter from all other air modes. Empty mail classes within a subpopulation retain the mailclass, but are redefined to a non-empty subpopulation. Equation (2.2) is the separate [stratum] ratio estimator formula with numerator component, $\hat{Y}rc_{A,S,r,c,h,i}$, shown in equation (2.3).⁹ Equation (2.3) is exactly equation (1.1), where $\hat{Y}rc$ in equation (1.1) is re-expressed to identify the mail class component (c) of a PSU explicitly (per its definition) instead of implicitly.

For air mode (A), the estimated total (Y) for mail category (r) is the sum of the subpopulation (S) estimates as follows:

$$(3.1) \quad \hat{Y}_{A,r} = \sum_S \hat{Y}rs_{A,S,r} .$$

For air mode (A), a distribution key element (r) in (K) for the weight, volume or cubic feet measure (y) is estimated as follows:

$$(4.1) \quad \hat{r}_{A,Y} = \frac{\hat{Y}_{A,r}}{\sum_{r \in R} \hat{Y}_{A,r}} .$$

Canada vs. Rest of World (ROW) Foreign Origin LC/AO Air and Surface

TRACS uses RPW weights to disaggregate both the Foreign Origin LC/AO Air and Foreign Origin LC/AO Surface into Canada vs. ROW. The distribution key proportions for Canada LC/AO and ROW LC/AO are developed as follows: The Canada and ROW aggregated proportion for each mode is reallocated to each group in proportion to their total RPW weights.

B. VARIANCE ESTIMATION

The TRACS Air subsystem estimator for the distribution key element, \hat{r}_{A,Y_r} , in equation (4.1) is a complex type estimator which incorporates auxiliary variable information for expansion ratios at each stage of sampling. It also incorporates mail class controls for various aggregate levels upon tieback to known EDW weight (lbs.) for the sampling period. Moreover, numerous estimates are

⁹ In equation (2.2), the sample total for stratum (h) in the numerator of the separate [stratum] ratio estimator is itself an estimate calculated as the sum of the combined ratio estimates, $\hat{Y}rc$, for the sampled PSU (i) totals in (h) from equation (1.1).

constructed each sampling period for each air mode and shape-based mail category within for the mail characteristics of interest: weight and volume.

An alternative to a direct (tractable) formula representation (or re-sampling methodology) for estimating sampling error is Taylor series (first order) approximation; wherein, sampling variation can be estimated among first-stage sampling units (ultimate clusters). To ensure that the sampling error estimates are conservative and not under-estimates (on average), the first-stage finite population correction (fpc) is ignored.

For air mode (A), the estimated variance of the total sum (Y) for mail category (r) is the sum of the stratum (h) variance estimates as follows:

$$\hat{V}_{A,r}(\hat{Y}_{A,r}) = \sum_{h=1}^H \hat{V}_{A,r,h}(\hat{Y}_{A,r})$$

where if $n_h > 1$,

$$\hat{V}_{A,r}(\hat{Y}_{A,r}) = \sum_{h=1}^H \frac{n_h}{n_h - 1} \sum_{i=1}^{n_h} (y_{hi.} - \bar{y}_{h..})^2$$

$$y_{hi.} = \sum_{j=1}^{mhi} w_{hij} y_{hij}, \text{ for}$$

$$w_{hij} = \left(\frac{\sum_{h \in c} X_{A,S,c,h}}{\sum_{h^* \in c} X_{A,S,c,h^*}} \right) \left(\frac{X_{A,S,c,h,i}}{\sum_{i=1}^n \hat{X}_{A,S,c,h,i}} \right)$$

, (shown in equations (2.1 and 2.2), and

$$y_{hij} = \hat{Y}rc_{A,S,r,h,i} \text{ (show in equation 1.1),}$$

$$\bar{y}_{h..} = \left(\sum_{i=1}^{nh} y_{hi} \right) / nh$$

And if $n_h = 1$,

$$\hat{V}_{A,r,h}(\hat{Y}_{A,r}) = \begin{cases} \text{missing if } nh' = 1 \text{ for } h' = 1, 2, \dots, H \\ 0 \text{ if } nh' > 1 \text{ for some } 1 < h' < H \end{cases}$$

For air mode (A), the standard deviation of the total sum (Y) for mail category (r) is as follows:

$$Std(\hat{Y}_{A,r}) = \sqrt{\hat{V}_{A,r}(\hat{Y}_{A,r})}$$

A relative measure of sampling error, coefficient of variation (c.v.), is estimated, $cv(\hat{r}_{A,Y})$, for each mail category element estimate ($\hat{r}_{A,Y}$) of the distribution key vector (\hat{K}). For air mode (A), the c.v. for each mail category element is as follows:

$$cv(\hat{r}_{A,Y}) = \frac{Std(\hat{Y}_{A,r})}{\hat{Y}_{A,r}}$$

C. EXPANSION PROGRAMS AND INPUTS

The programs and inputs used to expand sample data and generate the distribution keys and cv's are:

All air modes:

Program:	TRACSSMN.FEDEX.PQqfy.CNTL(KEYAIR3)
Inputs:	TRACSSMN.MAILCODE.FLAT.CODE.FYfy
Commercial Air	TRACSSMN.AIR.ZFILE.PQqfy.CAIR
FedEx Day	TRACSSMN.AIR.ZFILE.PQqfy.DAY
UPS	TRACSSMN.AIR.ZFILE.PQqfy.UPS

VII. Fed Ex Night Turn

The Fed Ex Night Turn distribution key is developed quarterly, based upon data from the SAMS, PTS, FPS system, and data regularly collected by TRACS.

The SAMS network collects dispatch and routing (D&R) information for the four main air carriers, or air modes. These air modes include Fed Ex Day Turn, Fed Ex Night Turn, Commercial Air, and UPS. The D&R tag identifies air mode specific information including the air carrier, origin and destination city airport codes, item weight and primary mail class. The primary mail class is the Air Contract Transportation (ACT) tag code. A mail item is assigned an ACT tag code based on the predominant mail class of the mail item's contents. The major mail class codes are: F, P, E and I. These correspond to First-Class Mail, Priority Mail, Priority Mail Express and International mail, respectively. We define all other ACT tag code mail class groups here as 'O' for 'other'.

The Night Turn frame is defined as the SAMS Night Turn total assigned D&R pounds. First, the frame is partitioned into these five different ACT tag components. Second, these five ACT tag components are then separated into two groups. The first group only contains ACT tag E. The other group contains the remaining ACT tags; F, P, I, and O. These two groups receive different treatments. We will first address the ACT tag E treatment.

A National Distribution List file is used to create an air mapping matrix by ZIP Code, Sectional Center Facility (SCF), and servicing air routing facility. Available ACT tag E data for five products, (Priority Mail Express, Express Mail International, Inbound EMS, Canada EMS, and USPS Priority Mail Express), is retrieved from the Product Tracking System (PTS). Since PTS does not have weight data for Inbound EMS and Canada EMS, the weight per piece data by origin country is collected from FPS, and merged with the PTS data. The PTS data is then merged with the air mapping matrix.

The PTS air matrix data is overlaid and merged with the SAMS data by ZIP Code. The SAMS data includes the primary mail class, ACT tag code summarized as 'E', class of Priority Mail Express. This SAMS data includes four major air modes; Fed Ex Day Turn, Fed Ex Night Turn, Commercial Air, and UPS. The PTS products are spread between the four air modes based upon the SAMS weight proportion. At this point the data is split into air and ground components. PTS control totals are used to create expansion factors for each PTS product. The air/ground split is based upon a ZIP Code merge that is dependent upon a cleaned data set. To account for data that fail to merge, the expansion factor, in equation 1.1, adjusts the data back to match the original control total.

The following notation is used in the calculation process:

A: Air mode;

AP: Air Product pounds;

c: mail class (ACT tag), $c \in \{E, P, I, F, "O"\}$;

G = Ground Product pounds;

i = 1,2,...5: $i \in \{\text{Priority Mail Express, Express Mail International, Inbound EMS, Canada EMS, USPS Priority Mail Express}\}$;

j = 1,2,...n: $j \in \{\text{All products allocated by TRACS to purchased transportation: First-Class Single Piece Letters, Presort Letters, etc.}\}$;

LB = total pounds;

lb-dk = Distribution key based on pounds;

m: mode, $m \in \{\text{Night Turn, Day Turn, Commercial Air, UPS}\}$;

OD: Airport Origin/Destination Pair;

ODZIP: Origin/Destination ZIP Code Pair;

P = Product pounds;

P_{PCNTL} = Product control pounds, after the air/ground split expansion factor and tare factor applied;

P_S = SAMS pounds;

T = Total Product pounds (before air/ground split).

(1.1)

$$\sum_{ODZIP} P_i = \sum_{ODZIP} P_i \times \frac{\sum_T P_i}{\sum_{AP,G} P_i}$$

Next, tare weight factors are applied to Priority Mail Express, Express Mail International, and USPS Priority Mail Express. Tare weight factors are not applied to the two international PTS products because the FPS weight data is already in gross pounds. TRACS sampling data from October 2011 through March 2014 were used in order to develop an unbiased estimate of Domestic and Outbound Priority Mail Express tare percentages. This includes data from

Commercial Air, Fed Ex Day Turn, UPS, and Fed Ex Night Turn. The results are displayed in the following table.

	Gross Lbs	Tare Lbs	Pieces	Piece Lbs	Tare %
Domestic Priority Mail Express	124,050	5,776	55,037	118,273	0.046563
Outbound Priority Mail Express	68,533	913	12,243	67,620	0.013324

Equations 1.2 through 1.5 demonstrate the transformation of the PTS product to be aligned with Air Mode 'E' pounds based upon SAMS proportions. The PTS product weight does not change.

(1.2)

If $\sum_{OD, ODZIP} P_s > 0$ then,

$$X_{ODZIP} = \frac{\sum_{ODZIP} P_s}{\sum_{OD, ODZIP} P_s}$$

$$X_{OD} = \frac{\sum_{OD} P_s}{\sum_{OD, ODZIP} P_s}$$

Else if $\sum_{OD, ODZIP} P_s \leq 0$ then,

$$X_{ODZIP} = 0$$

$$X_{OD} = 0$$

(1.3)

If $\sum_{ODZIP} P_s > 0$ then,

$$X_{A,m,ODZIP} = \frac{\sum_{ODZIP} P_{A,m,S}}{\sum_{ODZIP} P_s}$$

Else if $\sum_{ODZIP} P_s \leq 0$ then,

$$X_{A,m,ODZIP} = 0$$

(1.4)

If $\sum_{OD} P_S > 0$ then,

$$X_{A,m,OD} = \frac{\sum_{OD} P_{A,m,S}}{\sum_{OD} P_S}$$

Else if $\sum_{OD} P_S \leq 0$ then,

$$X_{A,m,OD} = 0$$

(1.5)

$$P_{A,ODZIP,i} = (P_{A,ODZIP,i} \times X_{ODZIP} \times X_{A,m,ODZIP}) + (P_{A,ODZIP,i} \times X_{OD} \times X_{A,m,OD})$$

Equation 1.6 constrains the PTS product by the SAMS control total:

(1.6)

$$\text{If } \sum_{A,m,OD} P > \sum_{A,m,OD} P_S,$$

$$\text{Then } \sum_{A,m,OD} P_i = \sum_{A,m,OD} P_i \times \frac{\sum_{A,m,OD} P_S}{\sum_{A,m,OD} P}$$

Equation 1.7 expands the products in the four air modes to the SAMS Air Mode weight control total:

(1.7)

$$P_{A,m,i} = P_{A,m,i} \times \frac{P_{A,m,S}}{\sum_{A,m} P_i}$$

At this point, equation 1.8 applies PTS product control pound totals to the Night Turn mode products.

(1.8)

$$P_{A, m = \text{Night}, i} = P_{A, m = \text{Night}, i} \times \frac{P_{PCNTL, m = \text{Night}, i}}{\sum_{A,m} P_i}$$

Equation 1.9 once applies SAMS Night Turn control totals to the Night Turn products.

(1.9)

$$P_{A, m = \text{Night}, i} = P_{A, m = \text{Night}, i} \times \frac{\sum_{A, m = \text{Night}} P_s}{\sum_{A, m = \text{Night}} P_i}$$

This concludes the treatment and development of the distribution key for the ACT tag 'E' portion of Fed Ex Night Turn frame. At this point in the process, the five PTS treatment products; Priority Mail Express, Express Mail International, Inbound EMS, Canada EMS, and USPS Priority Mail Express sum weight equals the Night Turn frame 'E' pounds, and the Night Turn 'E' distribution key is:

(1.10)

$$r_{A, lb-dk_{mci}} = \frac{LB_{mci}}{\sum_{mc} LB_{mc}}$$

where $m = \text{Night Turn}$, $c = E$, and $i \in \{\text{Priority Mail Express Mail, Express Mail International, Inbound EMS, Canada EMS, USPS Priority Mail Express}\}$.

The remaining distribution keys for the remaining four Night Turn ACT groups are developed by using other, available TRACS sampling air data. A distribution key by ACT tag is produced for each air mode and then weighted by the mode SAMS control ACT tag weight to produce a composite ACT tag

distribution key. For quarter 2, 'O Tag' pieces were not sampled due to randomness in the sample selection and low volume within the Frame. The 'O Tag' distribution from quarter 3 was used as proxy. The overall distribution is then recalculated by weighting the distribution key for each Act Tag by the total SAMS control ACT tag weight.

(1.11)

$$\mathbf{r}_{A,lb-dk_{ci}} = \frac{\sum_m (lb-dk_{mci} \times LB_{mc})}{\sum_{mc} LB_{mc}}$$

where $m \in \{\text{Day Turn, Commercial Air, UPS}\}$, and $c \in \{F, I, O, P\}$.

At this point, five distribution keys have been developed for each of the five ACT tag categories that have been assigned to the Night Turn frame. To create the final Night Turn distribution key, these five ACT tag keys are weight by their corresponding frame weight.

(1.12)

$$\mathbf{r}_{A,m=Night,lb-dk_i} = \frac{\sum_c (lb-dk_{ci} \times LB_c)}{\sum_{mc} LB_{mc}}$$

Canada vs. Rest of World (ROW) Foreign Origin LC/AO Air and Surface

TRACS uses RPW weights to disaggregate both the Foreign Origin LC/AO Air and Foreign Origin LC/AO Surface into Canada vs. ROW. The distribution key proportions for Canada LC/AO and ROW LC/AO are developed as follows: The Canada and ROW aggregated proportion for each mode is reallocated to each group in proportion to their total RPW weights.

Appendix C: Tables

Table 1(a): Letter and Flat Shape Mail Codes, Descriptions and Surface Density Factors

Mailcode	Shape	Description	Density (Lbs/Cu ft)
111	Letter	First-Class Single Piece Letters	16.1947
111	Flat	First-Class Single Piece Flats	22.5531
111	NM-Flat	First-Class Package Service (Retail)	22.5531
112	Letter	First-Class Presort Letters	17.6948
112	Flat	First-Class Presort Flats	23.633
113	Letter	First-Class Presort Letters	17.6948
113	Flat	First-Class Presort Flats	23.633
121	Letter	First-Class Single Piece Cards	16.1947
122	Letter	First-Class Presort Cards	17.6948
123	Letter	First-Class Presort Cards	17.6948
400	Letter	Periodicals	27.7784
400	Flat	Periodicals	27.7784
511	Letter	Marketing Carrier Route	21.0702
511	Flat	Marketing Carrier Route	27.9177
513	Letter	Marketing High Density and Saturation Letters	21.0702
513	Flat	Marketing High Density and Saturation Flats/Parcel	27.9177
514	Letter	Marketing High Density and Saturation Letters	21.0702
514	Flat	Marketing High Density and Saturation Flats/Parcel	27.9177
521	Letter	Marketing Letters	21.0702
521	Flat	Marketing Flats	27.9177
521	NM-Flat	Marketing Flats	13.3749
522	Letter	Marketing Letters	21.0702
522	Flat	Marketing Flats	27.9177
522	NM-Flat	Marketing Flats	13.3749
523	Letter	Marketing Letters	13.3749
523	Flat	Marketing Flats	13.3749
533	NM-Flat	Marketing Flats	13.3749
601	Flat	Package Svs Single-piece Parcel Post	8.3971
604	Letter	Package Svs Media Mail/Library Mail	18.479
604	Flat	Package Svs Media Mail/Library Mail	18.479
605	Letter	Package Svs Bound Printed Matter Flats	23.9404
605	Flat	Package Svs Bound Printed Matter Flats	23.9404

700	Letter	USPS Mail	17.6948
700	Flat	USPS Mail	27.9177
800	Letter	Free Mail	20.2793
800	Flat	Free Mail	20.2793
899	Letter	International Mail	
899	Flat	International Mail	
999	Letter	Competitive Mail	
999	Flat	Competitive Mail	

Table 1(b): Parcel Shape Mail Codes, Descriptions and Estimated Surface Composite Density Factors for FY19

Mailcode	Shape	Description	Density (Lbs/Cu ft)
400	Parcel	Periodicals	26.4586
521	Parcel	Std Parcels	6.6821
522	Parcel	Std Parcels	6.6821
523	Parcel	Std Parcels	6.6821
533	Parcel	Std Parcels	6.6821
604	Parcel	Package Svs Media Mail/Library Mail	16.391
605	Parcel	Package Svs Bound Printed Matter Parcels	19.9401
700	Parcel	USPS Mail	9.1168
711	Parcel	Premium Forwarding Service	17.2393
800	Parcel	Free Mail	14.2452
899	Parcel	International Mail	
999	Parcel	Competitive Mail	

Table 2: Known Item Size

Item Type	Known Cubic-Feet
Full size envelope tray	0.749
Half size envelope tray	0.374
Flat tub or box	1.490
Small parcel tray	2.813
Con-con	8.50

Table 3: Default Tare Weight Density Factors

Item Type	Density Factor (pound/ft3)
Sack with tare weight <=1.5 (lb.)	3.05
Sack with tare weight >1.5 (lb.)	6.66
Express Mail	3.05

Table 4: Known Container Size

Container	Default Cubic-Feet
3X MTE	106.67
BMC-OCR	110.61
ERMC	49.34
FSS Cart	24
GPC/GPMC/APC	48.64
Hamper	30.96
Other Wheeled	48.64
Short Postal Pak	42.22
Tall Postal Pak	76.67
Wiretainer	33.33